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Standard Practice for Estimation of Short-term Inhalation Exposure to Volatile Organic Chemicals Emitted from Bedding Sets[1]

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1. Scope

1.1 This practice covers the procedures for estimation of short-term human inhalation exposure to volatile organic chemicals (VOCs) emitted from bedding sets when a new bedding set is first brought into a house.

1.2 The estimated exposure is based on an estimated emission profile of VOCs from bedding sets.

1.3 The VOC emission from bedding sets, as in the case of other household furnishings, usually are highest when the products are new. Procedures described in this practice also are applicable to used bedding sets.

1.4 Exposure to airborne VOC emissions in a residence is estimated for a household member, based on location and activity patterns.

1.5 The estimated exposure may be used for characterization of health risks that could result from short-term exposures to VOC emissions.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to its use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1356 Terminology Relating to Sampling and Analysis of Atmospheres[2]

D 5116 Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products[2]

D 5157 Guide for Statistical Evaluation of Indoor Air Quality Models[2]

D 6177 Practice for Determining Emission Profiles of Volatile Organic Chemicals Emitted from Bedding Sets[2]

3. Terminology

3.1 *Definitions*—For definitions and terms used in this practice, refer to Terminology D 1356.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air change rate*, *n*—the volume of outdoor air that enters the indoor environment in one hour, divided by the volume of the indoor space.

3.2.2 *bedding set*, *n*—an ensemble that includes a mattress for sleeping and a supporting box spring.

3.2.3 *emission profile*, *n*—a time-series of emission rates of one or more compounds.

3.2.4 *exposure scenario*, *n*—a description of how and where an estimated exposure occurs, including (*1*) the location and emission profile of the product or material that causes exposure, (*2*) the indoor environment where the individual is exposed to airborne emissions from the product or material, and (*3*) the location and activity patterns of the exposed individual.

3.2.5 *potential inhaled dose*, *n*—the product of air concentration to which an individual is exposed times breathing rate times duration of exposure.

3.2.5.1 *Discussion*—The potential inhaled dose is different from the dose actually absorbed by a target organ.

3.2.6 *short-term exposure*, *n*—an exposure of one week or less in duration.

3.2.7 *volatile organic chemical*, *n*—an organic compound with saturation vapor pressure greater than 10^{-2} kPa at 25°C.

4. Summary of Practice

4.1 This practice describes procedures for estimation of inhalation exposure to VOCs emitted from new bedding sets (**1**)[3]. The estimation of exposure is based on the emission profiles for a bedding set, the environmental conditions in a residence where the bedding set is being used, and the location and activity patterns of an exposed individual. Emission profiles are derived from environmental chamber emission tests **2**(see Guide D 5116 and Practice D 6177).

4.2 Estimation of exposure involves development of exposure scenarios, modeling of indoor-air concentrations, and selection and calculation of exposure measures.

5. Significance and Use

5.1 The objective of this practice is to provide procedures

[1] This practice is under the jurisdiction of ASTM Committee D-22 on Sampling and Analysis of Atmospheres and is the direct responsibility of Subcommittee D22.05 on Indoor Air.

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[2] *Annual Book of ASTM Standards*, Vol 11.03.

[3] The boldface numbers in parentheses refer to the list of references at the end of the standard.

for estimation of human inhalation exposure to VOCs emitted from bedding sets. The estimated inhalation exposure can be used as an input to characterization of health risks from short-term VOC exposures.

5.2 The results of exposure estimation for specific raw materials and components, or processes used in manufacturing different bedding sets, can be used to compare their relative impacts on exposures.

6. Procedures for Exposure Estimation

6.1 The procedures for exposure estimation include development of exposure scenarios, modeling of indoor-air concentrations, selection and calculation of exposure measures, and model evaluation.

6.2 *Development of Exposure Scenarios*:

6.2.1 An exposure scenario describes how and where exposure occurs. In specifying the exposure scenario(s), include a description of (*1*) the emitting product or material, in terms of its age, emission profile, and location, (*2*) the indoor environment where exposure occurs, and (*3*) the location and activity patterns of an exposed individual.

6.2.2 *Emitting Product or Material*—For this practice, the emitting product is a bedding set. Specify the assumed age, emission profile, indoor location, and size of the bedding set of interest.

6.2.2.1 For a conservative estimate of exposure, assume that the bedding set has just been purchased and the wrapper is not removed until it is placed in the residence.

6.2.2.2 Estimate the emission profile using adjusted chamber air concentrations (Practice D 6177).

6.2.2.3 The indoor location for the bedding set is assumed to be a bedroom.

6.2.2.4 Select a size of bedding set that is appropriate for the size of the bedroom.

6.2.3 *Indoor Environment*:

6.2.3.1 Conceptualize the indoor environment as consisting of the following three zones: (*1*) the immediate vicinity of the bedding set; (*2*) the remainder of the bedroom in which the bedding set is located; and (*3*) the remainder of the house. Specify a volume for the entire residence and for each of the zones. For a typical volume of the total residence, use the average value (369 m^3) listed in the *Exposure Factors Handbook* (**3**). For a conservative value of the residential volume, use one of the 10th percentile values (147 m^3 or 167 m^3) listed in the *Exposure Factors Handbook.* See X1.1 for example calculations to determine the volumes for the bedroom and the vicinity of the bedding set.

6.2.3.2 To simplify calculations, the indoor environment can be considered as consisting of just two zones, the bedroom and the remainder of the house. Such calculations would result in less realistic yet useful estimates for screening purposes.

6.2.4 *Location and Activity Patterns*—Specify the locations of an exposed individual throughout a 24-h (or longer) period in relation to the two or three indoor zones previously described . Also specify the time spent outside the house, during which the individual is assumed not to be exposed to chemical emissions from the bedding set. See X1.2 for examples of location and activity patterns.

6.3 *Modeling of Indoor-air Concentrations*:

6.3.1 The two major steps in modeling are selection of a model and provision of model input parameters.

6.3.2 *Model Selection*—Select a model that is capable of estimating indoor-air concentrations in multiple zones and allows the user to specify various types of emission profiles in addition to the indoor zones, their volumes, their interzonal airflow rates, and zonal airflow rates to and from the outdoors. Three models that are known to meet these criteria are CONTAM (**4**), EXPOSURE (**5**), and MCCEM (**6**). All three models have been developed by or for U.S. government agencies, and are therefore in the public domain. Each model has advantages and disadvantages in terms of completeness, simulation capabilities, the user interface, and how it addresses exposure. For example, CONTAM has the capability of calculating airflows among zones whereas for EXPOSURE and MCCEM, the airflows need to be specified by the user; MCCEM includes a library of airflow rates for selected residences.

6.3.3 *Model Inputs*—In addition to emission profiles, indoor zones, and location and activity patterns as previously described, specify (*1*) an air change rate for the residence, (*2*) airflow rates among the indoor zones, and (*3*) parameters related to indoor sinks. Some models may also require or allow the user to choose a time step.

6.3.3.1 Select a value for the air change rate for the residence to be modeled. The air change rate for the residence with the outdoors has units of inverse hours (h^{-1}). A measured value for the residence representing the conditions to be modeled, if available, should be used as a first choice. An alternative is to select a value based on appropriate cases in the literature. For example, a conservative value in the range from 0.1 to 0.2 h^{-1} and a central value in the range from 0.4 to 0.6 h^{-1} were reported by Koontz and Rector (**7**) based on an analysis of measurements from several residential field studies. Representative values for the residential building stock are not available.

6.3.3.2 Multiply the air change rate by the zonal volume to obtain the airflow rate to and from the outdoors, in $m^3\ h^{-1}$. The simplifying assumption can be made that each zone has a balanced inflow and outflow with respect to outdoors. While this is generally not the case in a real building, one must have measured interzonal airflow rates or rates that were calculated with a multi-zone airflow model (such as CONTAM) to avoid using this assumption.

6.3.3.3 Use measured values, if available, for interzonal airflow rates between the bedroom and the remainder of the house. Alternatively, interzonal flows can be estimated using the CONTAM model (or some other multizone airflow model) or an equation such as the following:

$$Q = V(0.078 + 0.31N) \quad (1)$$

where:

Q = interzonal flow rate, m^3h^{-1}
V = volume of the house, m^3, and
N = air change rate of the house, h^{-1}.

The above empirical equation is based on an analysis of flow rates from several hundred nonrandomly selected residences (**7**).